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Barriers and opportunities of using the clean development mechanism to advance renewable energy development in China

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ABSTRACT

Studying the barriers and opportunities of using clean development mechanism (CDM) to advance renewable energy deployment in China has a practical significance to achieve its ambitious renewable energy plan which affects the global efforts to curb carbon emission. This paper analyses the role of CDM in promoting renewable energy development in China by reviewing the CDM activities, especially renewable energy CDM activities in China. There are three barriers to utilizing CDM for renewable energy deployment, namely the dilemma of additionality, lower proportional certified emission reduction credit revenues on the investment, and the lack of incentive for technology transfer. Whereas the opportunities of using CDM in promoting renewable energy development include the international carbon market redirection to renewable energy, Chinese renewable energy boom driven by a series of effective energy policies, and additional finance from CDM supporting Chinese renewable energy development. Based on the study on the barriers and opportunities, the article considers that CDM is an indispensable incentive and a viable choice to promote renewable energy deployment in China.

Contents

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1. Introduction

For China to become an economic power, it must accelerate industrialization and urbanization. These two processes are inevitable, but neither can occur without a commensurate increase in energy consumption and carbon emission. For example, International Energy Bureau predicts that Chinese coal demand will increase from 1734 million ton of coal equivalent (tce) in 2006 to 2712 tce in 2015, and to 3487 tce in 2030 [1]. Correspondingly, the carbon emission will increase certainly. This is not a good news for energy sustainable development and curbing carbon emission. Exploiting the energy in renewable energy rather than fossil energy to meet the future energy demand in China would create another scenario for climate protection as renewable energy is almost emission greenhouse gases.

Fortunately, the Chinese policymakers have noted the importance of renewable energy for curbing carbon emission. In September 2007, Chinese officials announced plans to nearly double the proportion of renewable energy in China's overall energy mix from 8% in 2006 to 15% in 2020 [2]. The targets are very realistic or even conservative based on what China has done thus far, that is till autumn of 2009. Wind power deployment is a good example. The initial target for wind power installed capacity set by *The Medium and Long-term Renewable Energy Development Plan* released on September 2007 was 5 GW by 2010 [2], but the cumulative wind installation was 5.91 GW in 2007 [3]. Then the target was up to 10 GW by 2010 in *The Eleventh Five-year Plan for Renewable Energy Development* [4]. Still the total of wind power installed capacity reached 12.15 GW by 2008 [5]. According to the current pace of development, China's total installed capacity in 2010 will be the second largest in the world, realizing the original plan of achieving the goal of 30 GW in 2020 a decade ahead of the schedule [6].

While China has taken substantial actions to increase its renewable energy use, renewable energy deployment in China, as many other developing countries face the constraints from finance and technology [7,8]. Additional revenues and the possible technological transfer from the clean development mechanism (CDM) provide a valuable opportunity to overcome the financial and technological constraints in China [8,9].

This paper discusses the barriers and opportunities of using CDM to advance renewable energy deployment in China. The paper will be organized as follows. The following section provides a short introduction to the CDM and a brief overview of CDM activities in China for readers who are not familiar with these. Next section surveys the status of utilizing CDM for renewable energy development in China. Section 4 analyses the barriers of CDM to advance renewable energy development in China. Section 5 studies the opportunities of CDM to stimulate renewable energy deployment. The conclusion identifies CDM is a viable choice and indispensable incentive to advance renewable energy in China.

2. CDM and China

2.1. Background information about CDM

A tough challenge to stabilize greenhouse gas levels at about 450–550 ppm carbon dioxide equivalence is how to engage developing nations in controlling greenhouse gas emissions [10]. On the one hand, developing countries are increasingly contributing to greenhouse gas emission because of their rapid economic growth, although developed countries are responsible for the majority of greenhouse emission in both past and present [11]. On the other hand, the developing countries have more immediate priorities, such as elimination of famine, poverty reduction, economic development, and community healthy improvement than curbing carbon emission. However, the developing countries should be part of any effective solution to curb carbon emission.

The CDM provides an institution to encourage developing countries to curb carbon emission. At the Conference of Parties 7 (COP7) in 2001, the Marrakesh accords is a set of agreements reached to pave the way for the implementation of CDM. The CDM was created by Article 12 of Kyoto Protocol in 2003. The CDM allows emission–reduction (or emission removal) projects in Non-Annex I (developing countries) to earn certified emission reduction credits (CERs), each equivalent to 1 ton of CO_2. These CERs can be traded and sold, and used by Annex I (industrialized countries) to meet a part of their emission reduction targets under the Kyoto Protocol with a cost-effective way. The detailed procedures of CDM are shown in Table 1.

The CDM is supervised by the CDM Executive Board (EB) and is under the guidance of the Conference of the Parties (COP/MOP) of the United Nations Framework Convention on Climate Change (UNFCCC). A CDM EB is authorized to define the detailed rules for the CDM project cycle and to accredit designated operational entities (DOEs) for validation, verification, and certification of proposed CDM project activities. Over 200 types of projects are eligible, including renewable energy, energy efficiency, forestry, and industrial gas capture, while large hydropower projects, nuclear projects and carbon capture and storage projects currently are not eligible. A crucial feature of an approved CDM carbon project is that it has established that the planned reductions would not occur without the additional incentive provided by emission reductions credits, a concept known as "additionality" [12,13]. Additionality is not only a principal condition for the eligibility of a project under the CDM, but also a requirement for validation.

The CDM is seen by many as a trailblazer. It is the first global, environmental investment and credit scheme of its kind, providing a standardized emission offset instrument. Being operational since the beginning of 2005, the CDM market has experienced an increasingly rapid growth (see Fig. 1) [14].

As per records, up to August 2009, the CDM has already registered 1792 projects and is anticipated to produce CERs amounting to more than 2.7 billion ton of CO_2 equivalent in the first commitment period of the Kyoto Protocol, 2008–2012 [15].

Table 1
Procedure of CDM project.

Step	Stage in project cycle	Participants	Resulting documents
1	Project development	Projects owner/project developer	Project design document (PDD)
2	Approval	Host country DNA (+ ev. Annex I country DNA)	Letter of approval
3	Validation	Designated operational entity	Validation report
4	Registration	Executive Board (EB)	EB decision
5	Monitoring	Project owner	Monitoring report
6	Verification	Designated operational entity (DOE)	Verification report
7	Certification	Designated operational entity (DOE)	Certification report
8	Issuance of CERs	Executive board, CDM registry	

Source: [12].

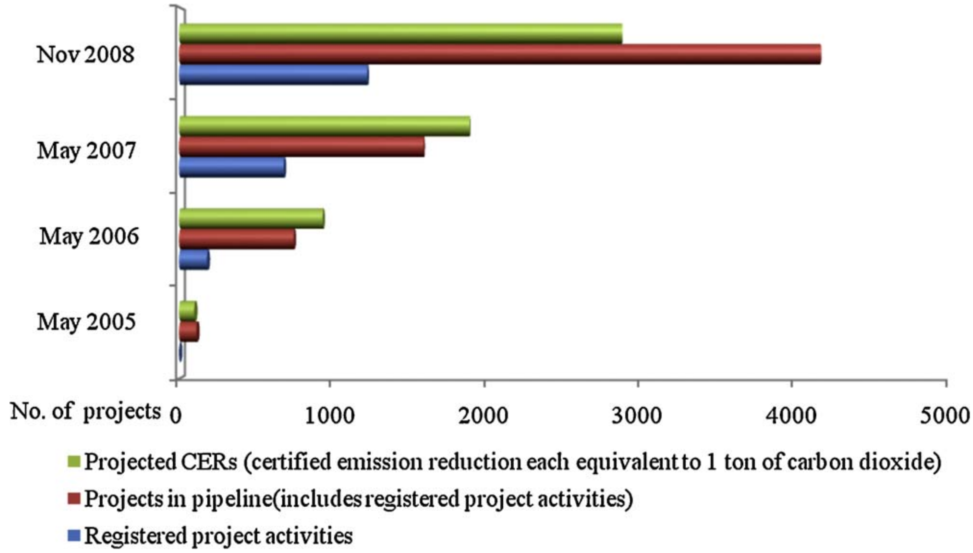


Fig. 1. Growth in projects, pipeline, projects CERs.Source: [14].

2.2. CDM activities in China

China took a relatively slow start in the CDM market until 2005. In August 2005, "*Measures for operation and management of CDM projects in China*" was issued. These measures provided a clear description for the requirements of the eligibility of project owner, intuitional arrangement for project management, documents needed for submission, detailed procedure for obtaining a letter of approval and priority area for CDM activities. Most of Chinese-specific CDM rules are part of these measures. The National Development and Reform Commission (NDRC) has been designated as China's Designed National Authority (NDA) and has the mandate to give host country approval to CDM project. In 2007, National Climate Change Coordination Committee (NCCCC), a cross-ministerial committee to coordinate national policy and activity relating to climate change was established. The NCCCC is also responsible for reviewing national CDM policies, rules and standards, and establishing the national CDM Board to operate the concrete program of the CDM activity. The daily work of NCCC is chaired by NDRC.

Such regulation, policy and institutional arrangement as mentioned above have promoted CDM activities rapidly since 2005. The number of registered CDM projects increases from 3 in 2005, to 36 in 2006, to 150 in 2007, and to 368 in 2008. Correspondingly, the expected annual carbon emission reduction of China's registered CDM projects has jumped from 34 million ton of carbon equivalent (t CO_2), to 46.39 million t CO_2 in 2006, to 92.17 million t CO_2 in 2007, to 134 million t CO_2 in 2008 [16].

China has been one of the most successful countries in harnessing the benefits of CDM. Since the first quarter of 2007, China has overtaken India to become the biggest CER suppliers not only in terms of CDM project numbers but also in terms of CERs volume. Until September 2009, the market share of registered project activities hosted by China is 35% (See Fig. 2), while the expected average annual CERs from registered project host by China is about 60% (see Fig. 3).

Up to September 2009, China hosted 640 registered CDM projects. Above three fourth of Chinese provinces hosted above 10 registered CDM projects, however, the geographical distribution is uneven. Six provinces hosted more than 30 registered CDM projects: 78 in Yunnan Province, 60 in Sichuan Province, 45 in Inner Mongolia, 43 in Hunan Province, 34 in Gansu Province, 32 in Shandong Province (see Fig. 4).

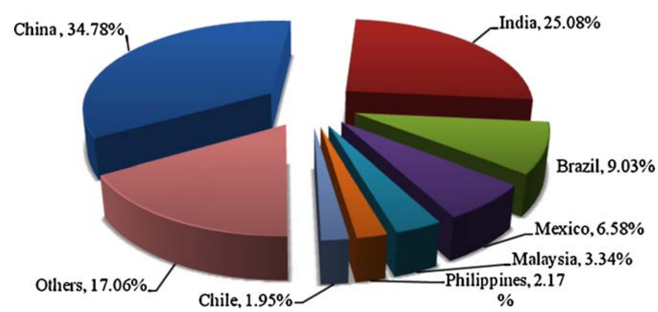


Fig. 2. Registered project activities by host party. Total: 1794.Source: [15].

A developed program includes a large variety of sectors, including HFC-23, methane recovery and utilization, energy efficiency, fossil fuel switch, wind mills, biomass energy, hydropower, solar and industrial projects. Looking at all the registered CDM projects in China until September 2009 (see Fig. 5), there are more renewable energy than other type energy (74.06%), followed by energy saving, efficiency improvement (10%), and methane utilization (6.25%). Other types of registered CDM projects include N_2O decomposition (3.91%), fuel substitution (2.03%), HFC-23 (1.72%), landfill power generation (0.78), afforestation and reforestation (0.16%). However, there is imbalance between the numbers of registered project and the expected average annual CERs (see Figs. 5 and 6).

Although renewable energy shared 74.06% of registered projects until September 2009, only 27.95% of China's expected average annual CERs are generated by renewable energy projects. On the other hand, projects that capture industrial greenhouse gas generate a sizable amount of CERs. HFC-23 projects in China are responsible for 33.53% of expected average annual CERs, while a number of HFC-23 projects account for 1.72% of registered CDM projects. And a number of N_2O registered projects account for 3.91% of the total but N_2O registered projects represent 12.53% of the expected average annual CERs [17].

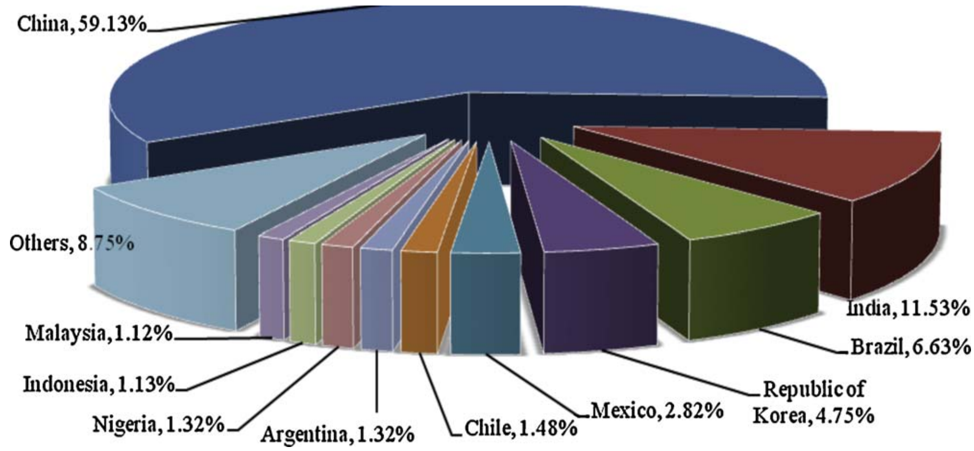


Fig. 3. Expected average annual CERs from registered projects by host party.Source: [15].

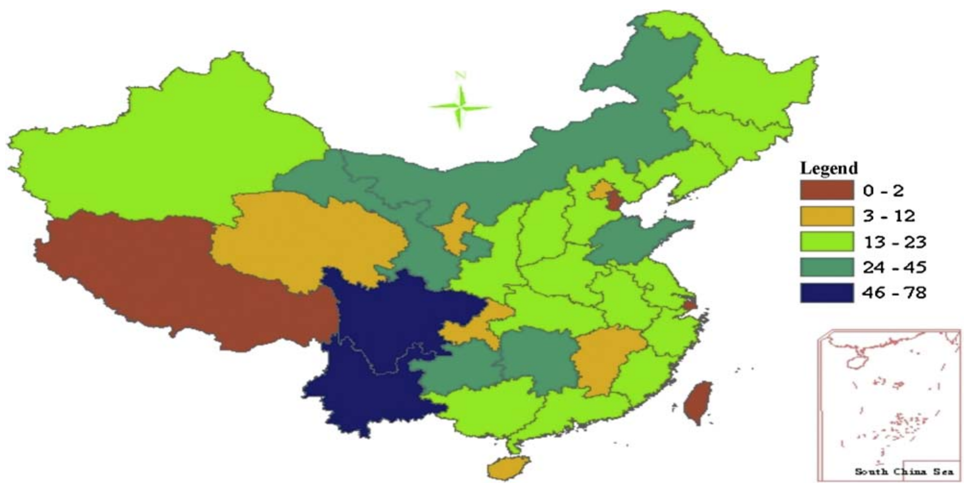


Fig. 4. The geographical distribution of registered projects in China until September 2009.Source: [17].

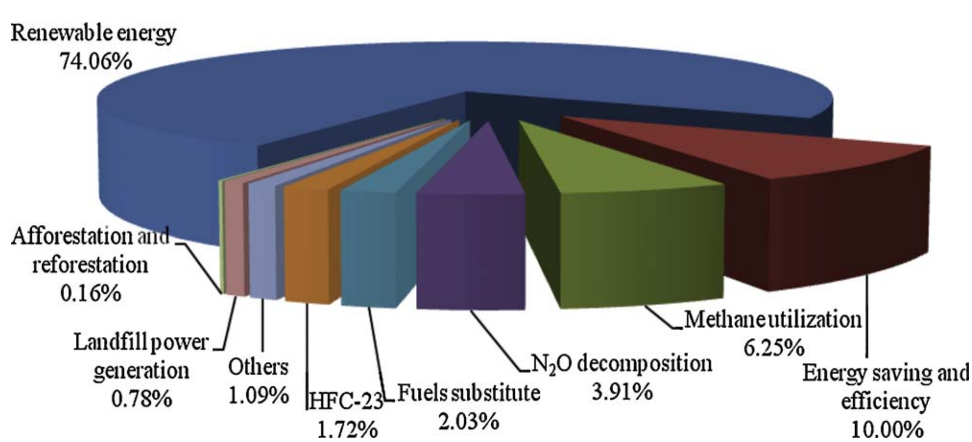


Fig. 5. Registered CDM projects in China until September 2009.Source: [17].

3. Utilizing the CDM for deployment of renewable energy in China

3.1. The pipeline CDM of renewable energy in China

China's late CDM projects developments have clearly gone into the direction to increased renewable energy CDM projects, while in its earlier phase largely China engaged in non-renewable energy CDM projects, such as HFC-23. According to the statistics of UNEP Risoe, the number of Chinese renewable energy pipeline CDM projects has reached to 1537, accounting for 83.48% of the total pipeline CDM projects in China until June 2009. The geographical distribution is uneven. Three provinces hosted more than 100 renewable energy pipeline CDM projects: 192 in Yunnan Province,

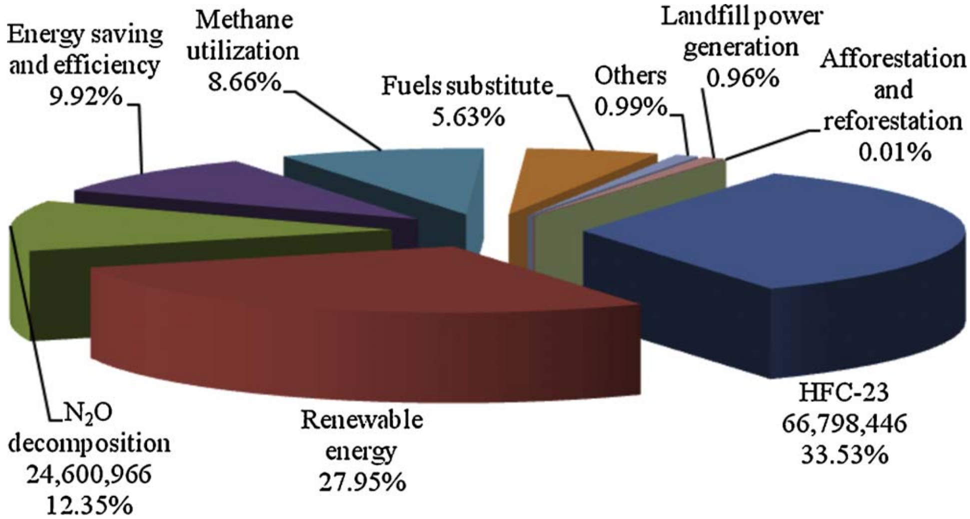


Fig. 6. Expected average annual CERs by scope in China until September 2009 (unit: t CO_2e).Source: [17].

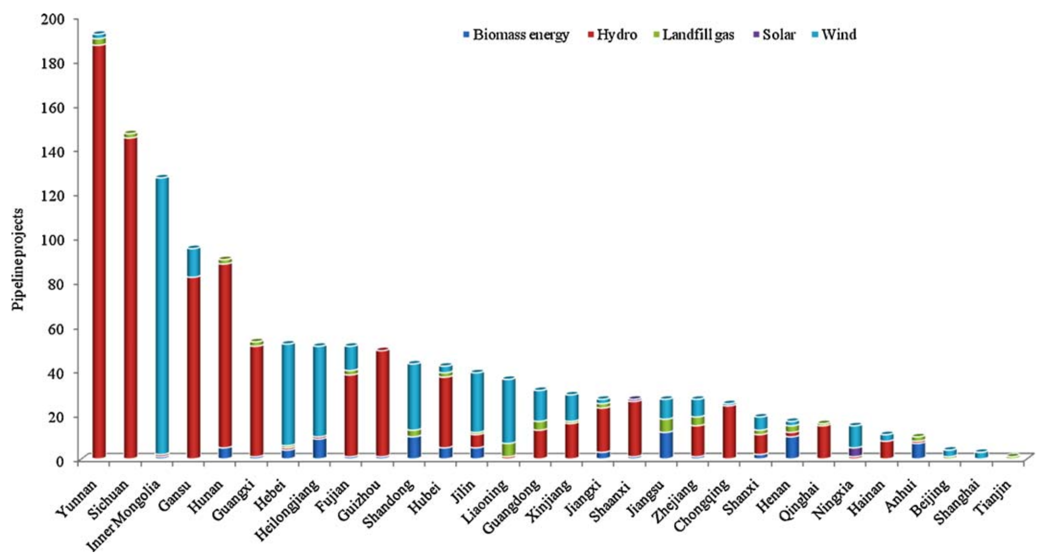


Fig. 7. Renewable energy pipeline projects by regions until June 2009.Source: [18].

147 in Sichuan Province, and 127 in Inner Mongolia. And six provinces hosted more than 50 renewable energy pipeline CDM projects: 95 in Gansu province, 90 in Hunan Province, 53 in Guangxi Province, 52 in Hebei Province, 51 in Heilongjiang province as well as in Fujian Province. There are also 12 provinces that hosted more than 20 renewable energy pipeline CDM projects [18] (see Fig. 7).

3.2. Type of renewable energy CDM projects

Hydropower ranks the first place in China's renewable energy pipeline CDM projects. Deployment of renewable energy in China is dominated by hydropower, while the gigantic hydropower is the most dominated one. By the end of 2008, China's total electricity installed capacity was 793 GW, of which hydropower accounted for 21.64%, after the coal-fired power (75.87% of total installed capacity). Among 173 GW hydropower installed capacity, <50 GW is small hydropower (<50 MW). Wind power ranks the second place after hydropower. Late years have witnessed the rapid growth of wind power in China. Total wind installed capacity was increased from 2.59 GW in 2006 to 5.91 GW in 2007 to 12.15 GW in 2008. The others are biomass energy, landfill gas, and solar energy.

The shares of renewable energy projects as illustrated in Fig. 10 translate into 50.5 GW of renewable energy capacity being proposed in the CDM pipeline. This includes 25.9 GW of hydropower, 22.2 GW of wind, and 2.1 GW of biomass energy, as well as 324 MW of landfill gas, and 13 MW of solar [18] (see Fig. 8).

The percentage of renewable energy projects as shown in Fig. 11 translate into 614,957 CERs of total expected accumulated 2012 CERs for renewable energy being proposed in the CDM pipeline. This consists of 331,581 CERs of hydropower, 197,125 CERs of wind energy, 53,224 CERs of biomass energy, 32,310 CERs of landfill gas, and 717 CERs of solar energy (see Fig. 9).

The dominance of hydro and wind projects primarily reflects the economics of renewable energy projects in China: hydropower and wind power are the least expensive forms of renewable energy in China. The subsidy value of a CER is not sufficient, on its own, to make solar electric energy financially viable in China. Although solar power is eligible, there have been only 4 solar projects in China applying for CERs to date, and they are solar cooking projects rather than photovoltaics [9].

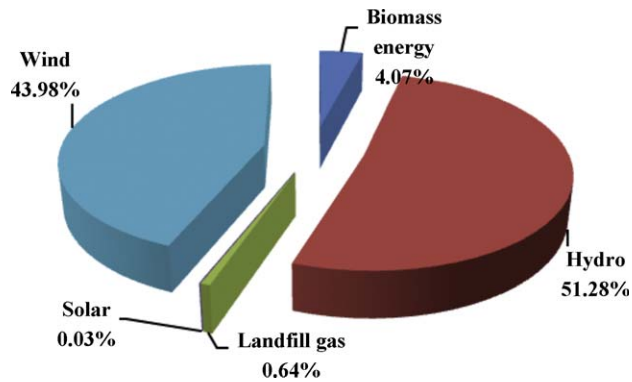


Fig. 8. Renewable energy registered projects by installed capacity/MW.Source: [18].

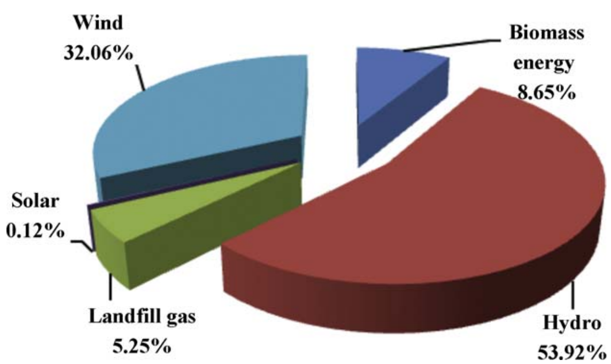


Fig. 9. Renewable energy expected average annual CERs by scope [18].

4. The barriers of using CDM to promote renewable energy in China

4.1. The barriers from "additionality"

Article 12 of Kyoto Protocol define emission reduction from CDM projects shall be "additional to any that would occur in the absence of the certified projects activities" [13]. According to Marrakesh accords, CDM projects are considered additional "if anthropogenic emission of greenhouse gases by sources is reduced below those that would have occurred in the absence of the registered CDM project activity" [12]. To estimate additionality, a baseline must be established which represents "business as usual" (BAU) emissions trends (projections of the "counter-factual" situation, i.e. if the project did not occur). The additionality requirement is justified. The CDM does not in itself reduce global emission; it is an offset mechanism allowing industrialized countries with a greenhouse gas reduction obligation to invest in projects that reduce emissions in developing countries. If a company decides not to reduce its own emissions instead purchases credits from a CDM project to offset them, and if this project is not additional, then global emissions increase.

However, the additionality would pose a "perverse" incentive for host countries not to implement ambitious policies for deployment of renewable energy [8,9,19]. Supposing a host country already has progressive policies for renewable energy development, it would be hard to testify that the project would not have occurred without the CDM. The developing countries might be discouraged to adopt and implement ambitious polices to promote renewable energy development and to curb the greenhouse gas emissions if the additionality would make them ineligible for CDM crediting. To address the dilemma, the CDM EB stipulated that the CDM would not to account national policies into the baseline calculation that have been implemented after November 2001 in avoid to punish national governments of CDM host countries that, e.g. pass progressive policies for the deployment of renewable energies. These so-called "E-policies" are not taken into consideration for baseline determination, but usually are considered in the project planning documents (PDDs) for the additionality test of a CDM project.

In the case of China, because the landmark *National Renewable Energy Law* and related provisions such as renewable energy support pricing policy were adopted since 2005, it should not affect the determination of an emission baseline for establishing additionality in the theory. However, the ambitious renewable energy policy sometimes is in conflict with the additionality in the practice. For example, the existence of renewable energy support pricing policy, such as a feed-in-tariff, sometimes are be used to question the financial additionality calculation of a project. While it is common for wind project developers in China to estimate a feed-in-tariff in the early stages of a project, this number may change after negotiations with the grid operator when the project goes online. Wind projects frequently end up receiving a tariff that is lower than what was initially forecast, which could make the role of carbon finance more important. However, this uncertainty in tariff-setting makes it even harder to prove financial additionality and the role of carbon finance in making a project viable. One wind energy CDM project has been rejected by the CDM EB due to additionality concerns [20]. In addition, a late report by Point Carbon shows that CDM EB has highlighted 15 wind projects in China that must be reviewed due to inconsistencies in the documentation of the level of government subsidy or feed-in-tariff [21].

4.2. Less competitiveness of renewable energy

The six greenhouse gases of the Kyoto Protocol are evaluated differently according to their potential to drive global warming, one prevented ton of, e.g. HFC-23 receives 11,700 CERs, while one prevented ton of CO_2 receives only one CER. Compared with other resources CDM projects (HFC, NO_2, and NH_4), the revenue of unit renewable energy (CO_2) CDM project is lower. Since renewable energy projects produce only small amounts of CERs, they are at a comparative disadvantage compared to other types of CDM projects.

Above all, renewable energy has the lower proportional CER revenues on the investment than other CDM projects. As shown in Fig. 10, chemical reduction projects, such as HFC and N_2O, and methane recovery and utilization, such as biogas, coal miners, and landfill gas projects are expected by 2012 with a total CER income twice as large as their initial investment. In these projects, CDM become the primary driver for the investment decision. On the contrary, renewable energy projects, whose total CDM revenue contribution until 2012 is below 20% of initial investment, include hydropower at 19%, fossil fuel switch at 16%, and wind power at 10% (see Fig. 10) [22].

The higher proportional CERs return on the investment of HFC-23 is illustrated by a HFC-23 incinerator at a HFC-22 plant in Quzhou, Zhejiang Province, Southeast China. While the incinerator would cost only $5 million to build, the plant would earn approximately $500 million in CERs [23]. The lower proportional CERs return on the investment of renewable energy is shown by wind power. Wind tariffs in China range from approximately 0.4 to 0.6 RMB (US cent 5.8–8.8)/kWh. However, the addition of carbon finance to a wind project in the form of CERs is only about 0.05–0.1 RMB/kWh [8]. The cost-effective nature of HFC-23 CDM project has driven the ramp-up of HFC-23 production in China. Compared with HFC projects, the proportional CERs return on the investment is too low to drive substantially renewable energy deployment in China.

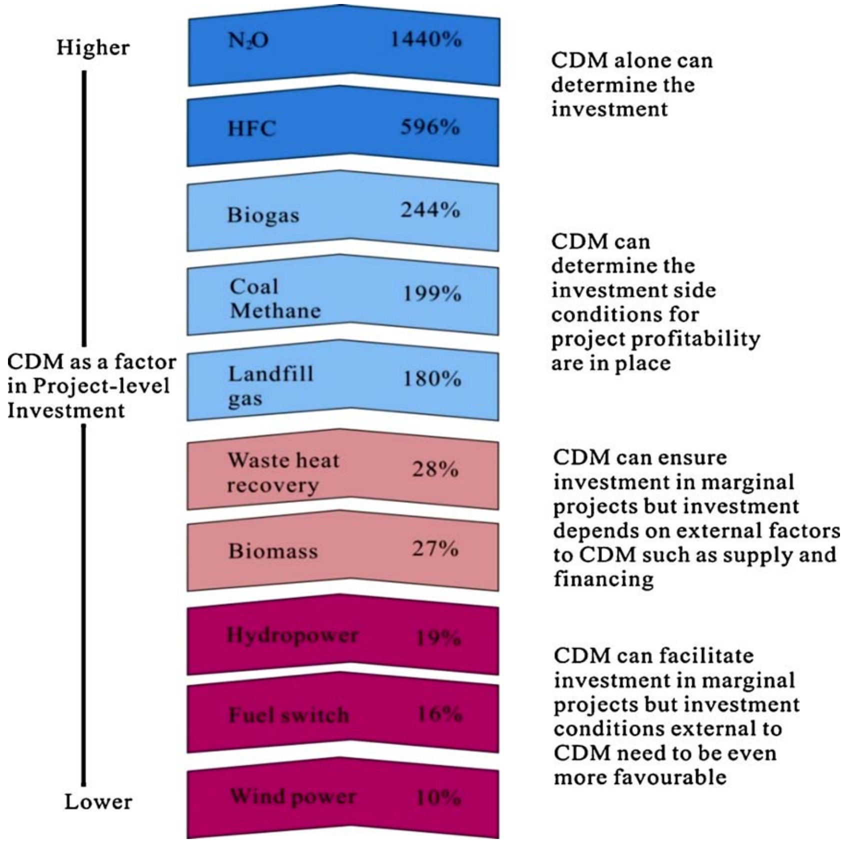


Fig. 10. CDM as a factor in project-level investment [22].

In addition, transaction costs of renewable energy as compared to the expected CER volume are higher than other CDM project types. Because the profit margin becomes larger than the most CERs issued for a project, project developers and buyers have a strong preference of large CDM projects generating millions of CERs with low transaction costs. Thus, HFC-23, rather than renewable energy CDM project is more popular in the carbon trade market.

4.3. Technology transfer

Access to exiting low-carbon technologies is very important for renewable energy deployment to avoid lock-in effect in energy infrastructure systems in China. The CDM does not have an explicit technology transfer mandate in Kyoto Protocol, however, the project participants are requested to "include a description of how environmentally safe and sound technology and know-how to be used in transferred to the host party" in CDM project design documents, as well as, technology transfer is identified as a key pillar in any agreement on a future regime to combat climate change in *Bali Action Plan–Document FCCC/CP/2007/L.7/Rev.1*. Moreover, Article 10 of *Measures for operation and management of CDM projects in China* explicitly encourages the transfer of environmental sound technology to China by CDM activities.

However, the renewable energy CDM projects have not substantially driven the technology transfer to occur. CDM contributes to technology transfer by financing emission reduction projects. As mentioned earlier, HFC-23 and N_2O CDM projects can receive the highest CERs, so the incentive from carbon market is enough to drive not only transfer equipment, but also involve significant amounts of knowledge transfer for HFC-23 and N_2O CDM project [24]. For example, although there is no other financial incentive for technology transfer of HFC in China, CDM project provides enough financial incentive to drive technology transfer from a French company named VICHEM. However, compared with HFC-23 and N_2O projects, the incentive from carbon market for renewable energy is too weak to trigger substantially technology transfer. The empirical analysis shows that the project-based CDM regime did not do well to foster the technology transfer. In most cases, the technology transfer had occurred before the implementation of proposed CDM projects and the CDM project only extended the scale of technology transfer. For example, Sinovel wind, Goldwind, and Dongfang Turbine, the leading Chinese wind turbine manufacturers, share almost 60% of the domestic market in 2008, commencing from buying license or buying design from overseas (see Table 2). Almost all CDM projects using wind turbine produced by these manufactures announced that there is no

Table 2
The technology source of Chinese leading wind manufacture.

Company	Rated capacity (MW)	Technology source
Sinovel Wind Co., Ltd.	1.5	Technology license/German Fuhrlander
	3.0	Buy design/Austria Windtec
	5.0	Buy design/Austria Windtec
Goldwind Co., Ltd.	0.6	Technology License/German Repower
	0.75	Technology License/German Repower
	1.5	Technology License/German Vensys
	2.5	Technology License/German Vensys
Dongfang Turbine Co., Ltd.	1.5	Technology license/German Repower
	2.5	Technology license/German Aerodyn

Source from the three companies' web site.

technology transfer. Few evidences show that CDM drive the new technology transfer in Chinese wind turbine [7].

5. The opportunities of using CDM to promote renewable energy in China

5.1. Time for CDM toward renewable energy in China

As mentioned earlier, the high global warming potential of HFC-23 means that reduction of quality of the gas yields roughly 11,700 times the number of CERs that would come from a project that reduced the same amount of CO_2. With their relatively low implementation costs and high reduction yields, HFC-23 projects represent the most cost-effective opportunities to make reduction in greenhouse gas emissions. The cost-effective nature of HFC-23 reductions has driven the ramp-up of HFC-23 production in developing countries. The largest share of CDM credits worldwide has been generated by the destruction of HFC-23 [10,15]. In China, 33.49% of CERs are generated by HFC-23 projects despite their small number of 11 projects in September 2009 [17].

However, criticism against the HFC mitigation projects has increased. Michael Wara criticizes that HFC-23 CDM project is a major distortion of the market, as HFC-23 emitters can earn almost twice as much from the CDM credits as they can start selling refrigerant gases [10]. HFC-23 CDM projects have provided large windfall profits for the chemical factory's owners and the consultants, rather than contributed to sustainable development in the host countries [8,10,22]. For these reasons, some buyers have begun to reject the HFC projects. This can be seen in the European Carbon Investors and Services (ECIS) Voluntary offset Standard (VOS) protocol, which has excluded HFC-23 projects from its list of accepted methodologies.

Meanwhile, renewable energy projects are currently more popular in carbon market than ever before. On the one hand, among the six greenhouse gases, CO_2 matters most because it is emitted in prodigious quantities and has a long atmospheric lifetime. The energy sector is generally the largest emitter of CO_2 in any country. Thus the market was expected initially to create strong incentives to invest in infrastructure for low-carbon energy in developing countries [10]. On the other hand, renewable energy projects seem especially apt to achieve both political goals of the CDM: cost-effective emission reduction and contribution to sustainable development [8].

The Chinese policymakers also have given priority to the renewable energy CDM projects. Renewable energy is identified as one of three priority areas (the others are energy saving and efficiency improvement) in China. The renewable energy, as priority project, is subject to a 2% fee on their CER revenue as "royalty fee", while the "royalty fee" on the CERs revenue from other CDM projects is higher: 65% from HFC projects, 30% from N_2O projects. The "royalty fee" collected from CERs revenue will be put into China CDM Fund to invest in climate change related activities like training, research, capacity building, and investment, thus helping renewable projects to reduce their competitive disadvantage to HFC or N_2O projects.

It is time for CDM toward renewable energy. The new trend of carbon market provides more opportunities for utilizing CDM to promote renewable energy deployment in China.

5.2. Renewable energy booming in China

Chinese government not only has noted the importance of renewable energy for Chinese sustainable development, but also has taken some effective energy policies to promote renewable energy development. Here we report some important ones related to CDM.

5.2.1. Renewable Energy Law

The landmark Renewable Energy Law was enacted in February 2005, and put into effect on January 1, 2006. This law is designed to "promote the development and utilization of renewable energy, improve the energy structure, diversify energy supplies, safeguard energy security, protect the environment, and realize the sustainable development of the economy and society" (Article 1) [25]. The law gave energy policy priority to the development and utilization of renewable energy [26]. Moreover, the crucial role of the landmark law makes China's renewable energy policy gain an overarching framework. The substance of the legal framework has been fleshed out in contemporaneous and follow-on regulations. Several governmental commissions and ministries have been involved in drafting the detailed regulations for the Law's implementation; more than 10 regulations have been issued with a couple of additional ones still contemplated.

5.2.2. Provisional administrative measure on pricing and cost sharing for renewable energy power generation

Three days after the *Renewable Energy Law* was put into effective, the NDRC issued "*Provisional administrative Measure on Pricing and Cost Sharing for Renewable Energy Power Generation*". According to the regulation, feed-in-tariff will be established for electricity from biomass project, for which a premium of 0.25 Yuna/KWh over the standard wholesale price for desulphurization coal-fired generating units has been approved, resulting in a feed-in-tariff between 0.55 and 0.60 Yuan/KWh. The regulation stipulated that the wind power price should follow the government-determined price. This price should be approved by the relevant department of the State Council based on the price of the tender. In addition, the regulations stated that the increment cost of renewable energy power generation over the standard wholesale price for desulphurization of coal-fired generating units shall be shared among the sales volume of electricity in power grids at the provincial and above level.

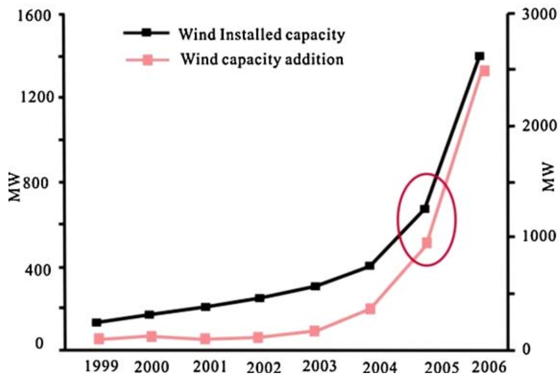
5.2.3. Renewable energy tax credit

Tax credits on renewable energy systems in China mainly include value-added tax (VAT) and income tax. The regular VAT of company in China is 17%, while VAT for companies in the renewable energy industryis 0% for ethanol production, 6.5% for small hydropower (<25 MW), 8.5% for wind power and 13% for biogas. And there is no more value-added tax on ethanol production since 2006. The income tax on revenues from biogas and wind power has already been reduced from 33% to 15%. For renewable energy CDM projects, these tax credits are taken into consideration for the investment return calculations in PDDs although these favorable taxes have been enforced after November 2001, the deadline for e-policies that need to be taken into account for CDM baseline scenarios.

5.2.4. Mid- and long-term plan for renewable energy

In August 2007, the Chinese government released the *Medium and long-term Renewable Energy Development Plan*. It states that the shares of renewable energy in the total primary energy consumption will increase from 7.5% in 2005 to 10% in 2010 to 15% in 2015 [2].

These effective support policies give enough incentives to invest into renewable energies in China. Wind power installed capacity is a good example. Wind power total installed capacity increased from 2.60 GW in 2006 to 5.91 GW in 2007 [3], and to 12.15 GW by 2008 [5]. By the end of 2008, renewable energy has increased to nearly 9% of China's total primary energy consumption [27], while renewable-based electricity shares almost 22% of China's total generated electricity [28].



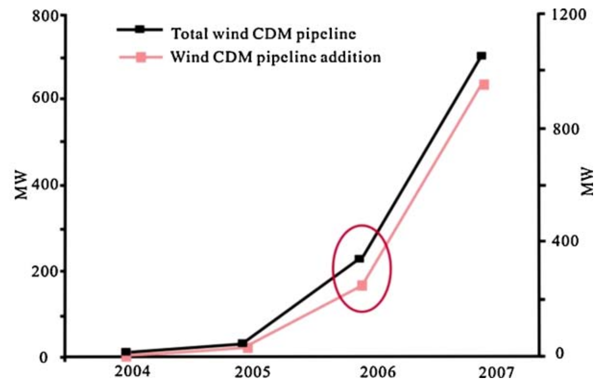


Fig. 11. Comparing growth in Chinese wind power and CDM wind projects.Source: [22].

It also should be pointed out that the rapid growth in renewable energy has positive correlation with the number of pipeline CDM projects. Take the wind power, the fastest growth renewable energy in late years. For example, as shown in Fig. 11, the development between the wind CDM pipeline and wind installed capacity is similar, although with a 1-year delay on the CDM side (See Fig. 11).

5.3. CDM contributing renewable energy deployment in China

Although the deployment of renewable energy in China is not dependent much on the usage of the CDM because it is financially contributing only little in comparison to investments needs, the revenue of CDM is indispensable for renewable energy deployment in China. This can be shown by the wind power development in China. Joanna I. Lewis examines the total number of wind farms that have requested CDM credits between 2003 and 2008, in order to examine the prevalence of CERs in supporting renewable energy projects in China. CDM wind capacity in each year is estimated based on the proposed start date of the crediting period as noted in the project description. Joanna's analysis shows that the majority of wind farms in China are requesting CERs. For example, about 72% of the wind farms built in China in 2008 would not have been built without the existence of the CDM (see Fig. 12).

In addition, the additional financial revenue from CDM project has substantially supported wind farm operation. From 2003 to 2009, wind projects with an installed capacity at or above 50 MW are authorized under a concession bidding process managed by NDRC. The wind concession bidding certainly stimulates the rapid growth in wind power installed capacity [6]. Wind installed capacity has been increased from 2.59 GW in 2006 to 12.15 GW in 2008 [5,29]. However, the concession bidding also brings unreasonable lower bidding price with the unwritten rule that the lowest bidding price usually wins the bidding. The biding winner prices vary between 0.38 and 0.52 Yuan (US cents 5.58 and 7.65)/kWh, which is quite a substantive reduction compared to common prices of the past. The winning bidding price is so low that a reasonable profit cannot be guaranteed [30]. As a result, the majority of wind farms in China have been struggling for livelihood, according to the latest report by State Electricity Regulatory Commission, a watchdog of Chinese electricity. In addition, about 1/3 of wind installed capacity now is idle [31], partly because the wind bidding price is too low. Wind CDM project is a viable choice to support wind farm's robust development in China. This is can be shown in the PDD of Jilin Tongyu Tuanjie wind project (100.3 MW), which becomes a concession project and a CDM project at the same time. The project owners "considered CDM as the only available option to make the investment financially viable".

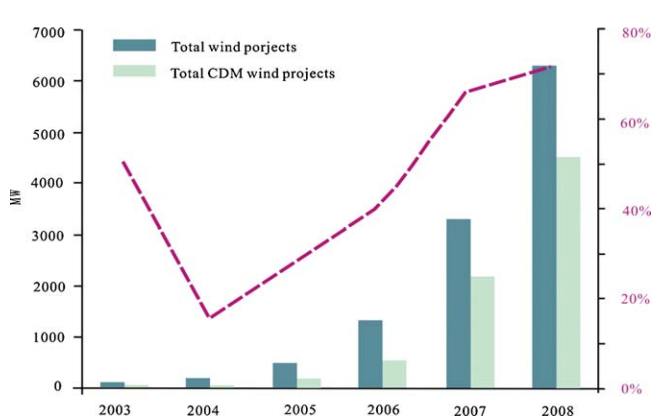


Fig. 12. Chinese annual installed wind power capacity and annual capacity requesting CERs.Source: [9].

6. Conclusion

China is currently the second largest energy producer and consumer, and is projected to overtake the US to become the first one by 2010 [11]. However, in the consumption of primary energy, the percentage of coal in China is 41% higher than the world's average [32]. Correspondingly, China has become one of the leading CO_2 emitters in the world. Exploiting the energy in renewable energy rather than in fossil energy in China is needed to curb carbon emission. CDM, as a trailblazer of international carbon market, provides an additional financial support for renewable energy deployment in China. We discuss the barriers and opportunities of CDM in promoting renewable energy development in China by reviewing the CDM activities, especially renewable energy CDM activities in China. There are three barriers to use CDM for renewable energy deployment, including the quandary of additionality, lower proportional CERs revenues on the investment, as well as the lack of incentive for renewable technology transfer. However, CDM is an indispensable incentive and a visible choice to promote renewable energy deployment in China, not only because the international carbon market has redirected to renewable energy and Chinese renewable energy is booming, but also because additional finance from CDM has supported Chinese renewable energy development.

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